MODIS DATA SYSTEM STUDY

TEAM PRESENTATION

August 19, 1988

AGENDA

1. Questionnaire
2. Synopsis of the July 22, 1988 Interview with Joule Susskind
3. Level 2/3/4 Data Products Requirements
4. Preliminary CDHF Block Diagram
5. Action Items

The July 13 and 26, 1988 interviews with WAYNE ESAIAS, which resulted in the most completely filled out questionnaire, are presented below.

INVESTIGATOR(S): W. Esaias **Date: July 13 & 26, 1988**

1. Parameter Name: **Ocean Chlorophyll Pigment (OCP)**

2. Definition: (include SI unit)

   Near surface concentration of the chlorophyll pigments.
   SI unit: milli-gram per cubic meter.

3. Spatial and Temporal Resolution and Coverage Requirements (include current capabilities and the goals for the MODIS)

   Spatial resolution: **1 km**

   Global coverage every two day interval

4. Accuracy Requirements
   (include current capabilities and the goals for the MODIS)

   +/- 30 %

5. Input Data Required:

5.1 MODIS sensor channels:

MODIS-T: all 64 channels

MODIS-N: 9 thru 15 to increase coverage when MODIS-T is is tilted; 34 (9.730 micro meter ozone channel).

5.2 Ancillary data:

- **solar spectral irradiance (1 per day) (ERBE(total)), currently used by GLADS & Mickle (long-term mean)**
- **wind stress (scatterometer, AMSU - 10 to 20 km) to eliminate surface reflection (Fresnel) in getting water leaving radiance.**
- **atm. pressure (NMC, Lidar - 10 to 20 km)**
- **aerosol types and concentration (MODIS, LASA, GLRS - every 10 km) .**
- **world map - CIA map (less than 0.01 deg x 0.01 deg) is used on-line w/ CZCS**
- **In-situ buoy radiance measurement (10 to 100 buoys)**

Note: Two to three tilt operations per orbit are sufficient for normal operations and can be planned 2-3 weeks ahead. Occasionally look at glint to study "slicks".

5.3 Delivery requirements:

6. Level 1 Processing Requirements

6.1 Calibration accuracy

+/- 2.5 %, basic is 1/4 of ocean leaving radiance. need calibration at level of 1 count: 1/4096 relative to solar spectral irradiance

vicarious calibration utilizing in-situ chlorophyll meas.

Note on digitization: Even with 12 bit digitization, gain changes are still needed to achieve full dynamic range of water leaving radiances (at final calibration accuracy). 15 bit dizitization will be needed to obviate gain setting changes.

Note on "Semi-analytical algorithm" - Partly empirical model of ocean layers radiative transfer, derived response functions, etc. (ref: H. Gordon et al.)

6.2 Calibration scenarios

On-board references:
lamps (once per week, once per month);
solar diffuser (once per orbit or less);
dark space (once per scan, several pixels only)
lunar (once or twice per month) - 10 % of the dynamic range of water leaving irradiance.

6.3 Instrument long-term stability requirements

6.4 Scenarios for monitoring instrument trend

- **In-situ buoys measuring ocean leaving radiance. (difficulty - atmospheric correction)**
- **Cruises measuring chlorophyll, etc. (several per yr.)**

6.5 Recalibration scenarios

- **"Post hoc"**

(Access to large volume of data required; reprocess every 6 months (one month to one year behind.)

- **Vicarious**

6.6 Earth location accuracy requirements
(include methods for attaining the stated accuracy)

- **Earth loc accuracy levied by land scientists is sufficient.**
- **one tenth of pixel absolute earth loc accuracy of 1 km pixels (i.e. 100 m @ nadir w/ zero tilt).**

Note: Use platform data only (no ground control points).

6.7 Level 1 data products

6.7.1 Description of Level 1A data products:
(list ancillary data to be merged with sensor data; list auxiliary database needed)

- **1A - counts from instrument; appended {calibration constants and earth location info.)**
- **1A' - only when viewing cal targets (?).**

6.7.2 Description of Level 1B data products:
(include strategies for segmentation, and logical record organization)

Calibration and earth location applied.

6.7.3 Desired distribution media:

6.7.4 Delivery requirements

6.8 References (for calibration, trend analysis, earth location)

7. Parameter Retrieval Algorithms

7.1 Algorithm description: (include description of how input data are used by the algorithm)

- **Corrections for molecular (Rayleigh) and aerosol (mie) scattering;**
- **Ozone absorption correction;**
- **About 64 channels used to model ocean radiative transfer to derive geophysical properties. (could be a matrix inversion at this stage (level 2) to derive water leaving radiances.)**

7.2 Limitations of the algorithm (e.g., accuracy limitation, limited parameter range of validity, etc.)

With sensor radiance accuracy at the level of 1 digital count, about 20 % limitation is imposed by algorithm for chlorophyll retrievals. However, a more sophisticated algorithm that determines other types of pigment would do much better than 20 % biomass.

7.3 Discussion of algorithm development status

"The more sophiscated algorithm", mentioned in 7.2, is yet to be developed; work has begun, and people have used principal component analysis of an eight band imager (SEAWIFS?); final algorithm development will need a global dataset from MODIS.

(see Reference listed in 7.5)

7.4 Estimates of computing resources:

7.4.1 CPU

will need to process the entire dataset several times per year.

7.4.2 Memory

7.4.3 Lines of code (specify language)
6 million loc in FORTRAN (Display System Program, of which the CZCS processing system is a part; Feldman,Miami)

7.5 References

H. R. Gordon et al., "A Semi-Analytical Model of Ocean Color", J. Geophys. Res. (in press)

8. Level 2 Data Products

8.1 Estimate of data volume

64 water leaving radiances + 12 geophysical parms per pixel:
daily data volume in bytes = (no. parms) x (no.pixels/sec) x (ocean/globe)x(daytime/day)x(86400 sec/day)x(2 B/parm)
= (76)x(1294x64x/9.7)x(2/3)x(1/2)x(86400)x(2)
= 37.4 (Gigabytes/day)

Earth location: 4 byte latitude and 4 byte longitude for each pixel (equivalent to 4 parameters): 1.97 GB/day

Level 2 data volume estimate: 39.4 GB/day.

8.2 Desired distribution media: (???)

8.3 Delivery requirements: (???)

9. Level 3 Requirements

9.1 Description of standard mapped data products:
(include bin sizes for spatial and/or temporal averages; also indicate type of projections desired (e.g.,Mercator and/or polar stereographic projections)

spatial and/or temporal averaging: 20 km @ equator; daily, weekly, monthly, seasonally, annually.

12 geophysical parameters + 28 water leaving radiances; (12+28) standard deviations;
2 additional parameters (n = no. of pixels per grid; N = total number of pixels)

For each of these quantities, need a two-dimensional arrays of size 2048x1024.

For each of 10 small regions (@20 km resolution), a 512X512 array is needed for mothly averaged pigments w/o statistics. (this type of Level 3 datasets shall be available on-line)

9.2 Estimate of data volume

- **40 arrays of size 2048x1024 for global map:**
  (40)x(2048x1024)x(2 B/grid point)(1 + 1/7 + 1/30)
  = 197 (MB/day) (Seasonal and annual arrays are ignored)

- **12 arrays of size 512x512 for 10 selected regions:**
  (10 regions)x(12)x(512x512)x(2 B/grid point)
  = 62.9 (MB/Month) (On-line storage requirement)

9.3 Desired distribution media

cassette tape or optical disk

9.4 Delivery requirements: **(TBD)**

10. Validation Requirements

10.1 Use of in situ data

10.1.1 Description of in situ data: (include accuracy requirements)

- **Radiance (Llamda+/-) +/-5 %**
- **In-water reflectance (Rlamda) +/-5%**
- **Pigment concentrations (15 each)**
- **Profiles of downwelling spectral irradiance**
- **klamda - diffuse attenuation coefficient**
- **Seston - suspended matter concentration +/-2 %**
- **Calcium carbonate concentration (CaCO3) +/-2 %**
- **Species enumeration**
- **Atmospheric properties "Langley plots at several lamdas"**
- **SST**
- **Profile of water temperature (500 meters from surface)**
- **Primary production: biomass/time/area**

10.1.2 Description of in situ experiment: (in situ experiment planned for supporting MODIS or currently ongoing experiment that may help validating MODIS-derived parameters)

- **Array of buoys visited by ships every 4 months**
- **Ships carrying 23 scientists and technicians**
- **20 buoys globally for measuring radiances, pigment concentrations, and fluorescences**

10.1.3 Comparison procedure: (describe how the MODIS-derived parameter values are compared with the ground truth measurements. include descriptions of statistical methods, mapping overlays, mathematical methods of analysis, graphical methods, etc.)

- **Calculate water leaving radiances from in-situ; then compare them with MODIS-derived water leaving radiances.**

- **Calculate geophysical parameters from in-situ-derived water leaving radiances;**
  Calculate corresponding parameters from MODIS-derived water leaving radiances;
  Compare underway (track lines) with the transects taken off MODIS-derived image.
- **Measure properties - use models to predict water leaving radiances.**

10.1.4 Description of current in-situ validation efforts:

- **CZCS - 2 cruises; no buoys.**
- **There are now 5 optical moorings to be used on SEAWIFS.**

10.1.5 Near real-time requirements for field experiments or target-of-opportunity observations

- **One day turnaround time.**
- **1000 km x 1000 km quick-look for selected bands.**

10.1.6 References for in situ experiment and validation efforts

10.2 Use of geophysical model(s)

10.2.1 Description of the model

Semi-analytical model (radiative transfer model) of ocean.

10.2.2 Description of model inputs:
(include accuracy of the model)

Model too new.

10.2.3 Procedures of using the model for validation:
(include descriptions of analysis methods and accuracy limitations)

No model like GCM exists for global pigments that is relevant on a daily basis. (It would take a Cray about 3 years to simulate ocean basin physics.

10.2.4 Discussion of current modeling validation efforts

None exists.

10.2.5 Estimate of computing resources:

10.2.5.1 CPU

10.2.5.2 Memory

10.2.5.3 Lines of code (specify language)

10.2.6 References for modeling validation efforts

11. Browse Data Products

11.1 Product descriptions:

- **Level 3 - can all be placed on CD ROM.**
- **Subset of Level 2 - on CD ROM**
  (4 bands, 4 pigments, aerosol - total about 10) (??)

11.2 Estimate of data volume

- **Level 3 - 199 MB/day (see question 9.2)**
- **Level 2 - (10/80)x39.4 = 8 (GB/day) (see question 8.1)**

11.3 Frequency estimate

- **Level 2 - daily**
- **Level 3 - daily and weekly**

12. Existing Data Products from Precursors to MODIS

12.1 Brief description of products:
(identify sensors and aircrafts and/or spacecrafts that carried the sensors)

- **S/C :**
  Nimbus-7 CZCS
  NOAA Tiros-N AVHRR (Miami)

- **A/C:**
  AOCI Ames
  AVIRIS JPL

12.2 References

SYNOPSIS OF THE JULY 22, 1988 INTERVIEW WITH JOULE SUSSKIND

A preliminary discussion of the MODIS data processing questionnaire was held with Dr. J. Susskind. Dr. Susskind was interviewed by Drs. E. Hurley and S. Kim. The discussion centered on the role to be played by MODIS-N in providing atmospheric observations in the EOS era, and involved the interplay of three major instruments that will be on the first polar platform. The instruments are MODIS, AIRS, and AMSU.

The following parameters will be derived from observations made by these three instruments: atmospheric temperature profile, surface temperature, atmospheric water vapor profile, cloud fraction, cloud top temperature, outgoing longwave radiation, and total atmospheric ozone.

The data processing of MODIS observations was discussed in the context of the observation pattern produced by the AIRS. AIRS will make 18 km resolution (IFOV) soundings every 40 km; so that within a 60 x 60 km^2 grid there will be four AIRS soundings. AIRS provides the highest possible vertical spatial resolution while MODIS provides vertical soundings at the highest horizontal spatial resolution. MODIS also can make contiguous observations. The unique advantages of each of the two sensors will be used in the data processing scheme to derive geophysical parameters of the highest possible resolution and accuracy.

Processing contiguous MODIS sounding and cloud observations into atmospheric soundings for any significant region will place an enormous burden upon the processing system. This is because the radiative transfer inversion calculations required at the level 2 stage of processing are computationally intensive. For example, MODIS soundings and cloud amounts, derived every four km to fill a 60 x 60 km^2 grid, would require over 75 hours on the CYBER 205.

There is also a requirement to process MODIS soundings at full resolution, i.e., every 1 km. This will have to be carefully planned to limited special events and limited geographical regions.

The data processing concept discussed by Susskind will involve merging of the AIRS and MODIS data prior to level 2 processing. interest.

LEVEL 2/3/4 DATA PRODUCTS REQUIREMENTS

These high level requirements are presented for review. They contain assumptions which may be changed as the overall requirements of the MIDACC are refined and additional requirements are identified. More detailed, geophysical parameter specific, level 2/3/4 requirements will be developed based upon input from scientists involved in the development of the MODIS facility and from the members of the MODIS Science Team when they are selected.

1. The level 2, 3 and 4 processors shall each have the capacity to process 24 hours of data within 12 hours of the next 24 hour period.

2. The level 2/3/4 processors shall also be capable of performing reprocessing, special request processing, near real- time processing, and backlog processing, in addition to the standard processing to produce the level 2/3/4 data products.

3. The level 2 processor shall receive level 1B data and any ancillary data necessary for the level 2 processing step.

4. The level 3 processor shall receive level 1/ 2 data and any ancillary data necessary for the level 3 processing step.

5. The level 4 processor shall receive level 1/2/3 data and any ancillary or correlative data necessary for the level 4 processing step.

6. The level 2/3/4 products shall contain all of the information necessary for the creation of catalogs and inventories of the level 2/3/4 data, and this information shall be passed on to the next level of processing.

7. The basic level 2/3/4 data product time spans shall be TBD.

8. The spatial and temporal resolution of scientific parameters contained in the level 2/3/4 data products shall be TBD.

9. The level 2 product shall contain geophysical parameters derived from the level 1B data by the application of geophysical parameter algorithms.

10. The level 2 data product format shall be similar to that of the 1B data, i.e., orbital swaths of geophysical parameter values plus appended information.

11. The level 3 data product shall contain Earth gridded geophysical parameter data including radiances, etc., form level 1 averaged or composited in time and in space.

12. The level 4 product shall contain TBD analyses of the lower levels of MODIS data products.

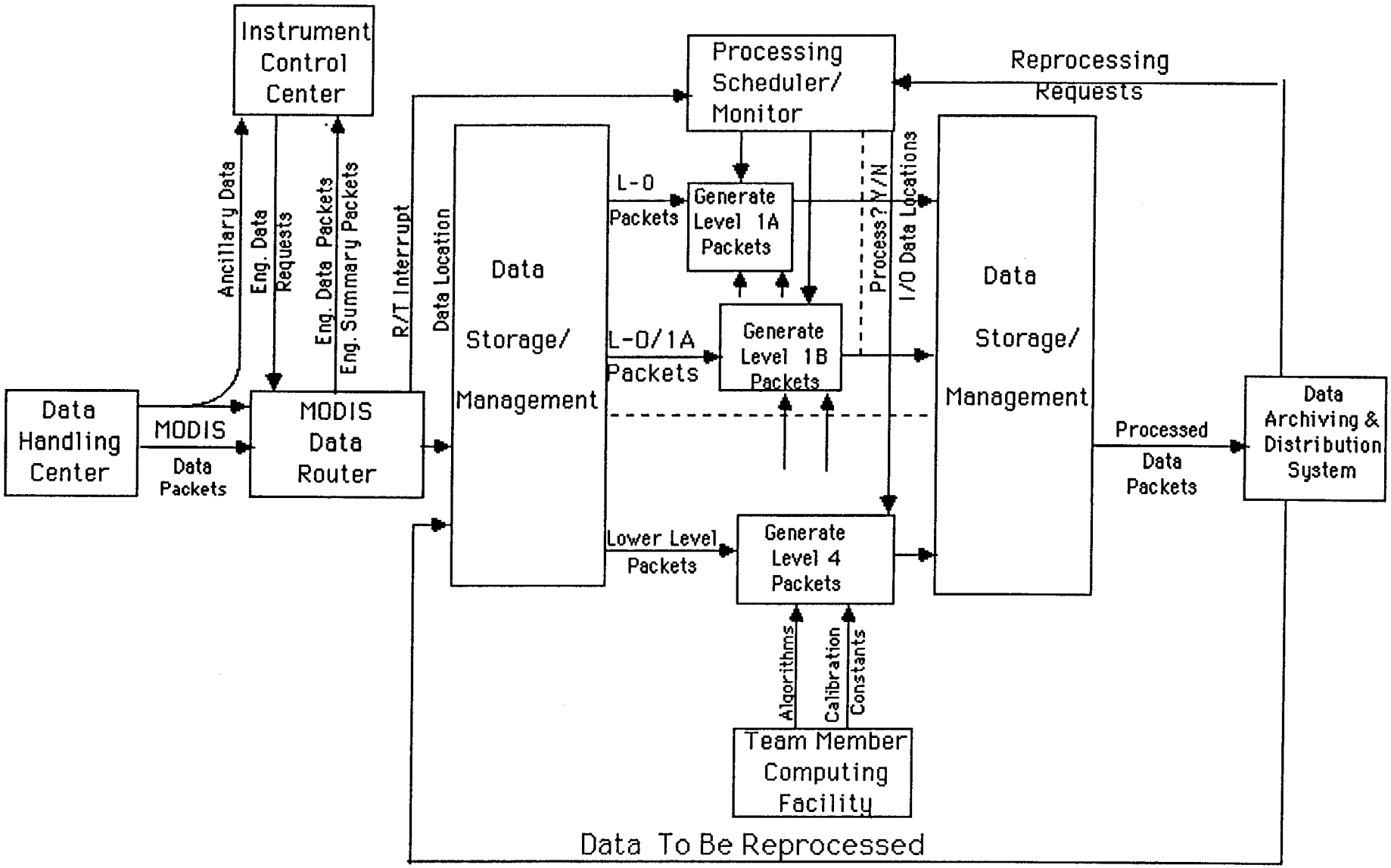
13. The level 3/4 data product formats shall be TBD.

14. The level 2/3/4 data products shall have appended to the various levels of data organization (from the basic product length to the lowest level of segmentation or gridding), TBD appended information from the lower level input data, geophysical parameter identification(s), geophysical parameter algorithm version identification(s), gridding description and statistics for level 3, correlative data information for level 4, geophysical or applications model identification for level 4, data quality assessment information, processing date, and version number.

15. The word sizes for level 2/3/4 data products are TBD.

16. TBD data compression shall be applied to TBD level 2/3/4 products.

CDHF BLOCK DIAGRAM
PRELIMINARY/INCOMPLETE
19 AUGUST 1988



ISSUES/OMISSIONS/QUESTIONS

- Control of Instrument Packet Contents
- Designation of Packets for Special Handling
- Centralized Generation of Graphic Images
- Real-Time Output from DADS
- Generation of Browse Data

ACTION ITEMS:

7/8-3 (Han) Review the draft data product questionnaire with members of the MODIS Instrument Team. ** Sent out for comment **

7/15-1 (Han) Confirm the 10 and 20 megabit per second data rates projected for low data-rate instruments and the platform LAN. ** closed **

7/29-1 (McKay) Fully analyze the scope and implications of the following EosDIS resource bottlenecks with respect to the MODIS data system: communications link between ground and platform, on- board LAN, on-board mass storage, and on-board processor. ** closed **

8/12-1 (McKay) Resolve the question as to whether the NOAA instruments (e.g., AMRIR) will share the on-board LAN; if so, will this be wiithin the 20 Mbps maximum capacity?